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WADC TECHNICAL REPORT 52-146

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EVALUATION OF FIRST ARTICLES OF PRODUCTION RADIO RECEIVING SET AN/ARN-18

BERNARD H. DELL
COMMUNICATION AND NAVIGATION LABORATORY

JULY 1952

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WRIGHT AIR DEVELOPMENT CENTER

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Bernard H. Dell
Communication & Navigation Laboratory

July 1952

SEA No. S-2

Wright Air Development Center
Air Research and Development Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

McGregor & Werner, Inc., Wakefield, Mass.
Oct. 22, 1952 100

FOREWORD

This report was prepared by the Communication and Navigation Laboratory, Wright Air Development Center, to record the results of tests conducted on First Articles of Production of Radio Receiving Set AN/ARN-18 developed and produced by Crosley Division, AVCO Manufacturing Corporation, under Contract No. AF 33(038)-18561; Emerson Radio and Television Corporation under Contract No. AF 33(038)-18559; and Pacific Mercury Television Corporation under Contract No. AF 33(038)-18560. Mr. William F. Neill, Mr. Leon F. Vangunten, and Mr. Bernard H. Dell were the Communication and Navigation Laboratory project engineers. The evaluation was conducted under Service Engineering Account S-2, "Work Performed for the Directorate, Procurement and Industrial Planning."

ABSTRACT

Crosley Division, AVCO Manufacturing Corporation; Emerson Radio and Television Corporation; and Pacific Mercury Television Corporation were simultaneously awarded contracts to develop and produce Radio Receiving Sets AN/ARN-18 (Glide Slope Receiver) in accordance with Military Specification MIL-R-6201 dated 31 August 1950. MIL-R-6201 was written so as to combine the better features of development 20-channel glide slope receivers designed by Collins Radio Company and Federal Telephone and Radio Corporation. The receiver was developed jointly by the three contractors who pooled their engineering facilities and performed most of the work at the Crosley Division plant. Six First Articles of production were built at Crosley and submitted for tests and approval. The results of the tests conducted on these First Articles indicated that the receivers failed to meet some of the requirements of Specification MIL-R-6201. However, this receiver represented an improvement over the development models AN/ARN-18(XA-1) and AN/ARN-18(XA-2), and a considerable improvement over the Air Force Standard, Radio Receiving Equipment AN/ARN-5( ). In the opinion of the WADC project engineers, the design was as good as the current state of the art would permit. Therefore, during the pilot runs, which had their inception in August 1951, production approval was granted to all three contractors.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDING GENERAL:

Harry E. McAfee
Lt Col USAF
for DANIEL B. WHITE
Colonel, USAF
Chief, Weapons Components Division

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SECTION I - INTRODUCTION

On 3 January 1951 contracts were awarded to Crosley Division, AVCO Manufacturing Corporation; Emerson Radio and Television Corporation; and Pacific Mercury Television Corporation to develop and produce Radio Receiving Set AN/ARN-18 (Glide Slope Receiver) in accordance with Specification MIL-R-6201, dated 31 August 1951. This specification had been written so as to combine the better features of two development radio receiving sets as designed by Collins Radio Company, and Federal Telephone and Radio Corporation. (For an evaluation of these development models refer to Air Force Technical Report 6744, titled "Evaluation of Development Radio Receiving Sets AN/ARN-18(XA-1) and AN/ARN-18(XA-2)."

In the interests of uniformity of design, the three contractors agreed to design the receivers as a joint project at the Crosley Division plant. All drawings and schematics were reproduced at Crosley and forwarded to the other two plants for use in setting up the production facilities. Thus it was possible for all three manufacturers to produce equipment which would be completely electrically and mechanically interchangeable. Six First Articles of production were fabricated at Crosley for submission to W-P AFB for evaluation and acceptance under the contracts. In view of the fact that each contractor was obligated to furnish First Articles, nameplates of each contractor appeared on two of the six First Articles submitted. However, they were all fabricated at Crosley using Crosley parts and production methods.

This report presents the test results obtained and an evaluation of the First Articles as compared to the applicable requirements of MIL-R-6201, showing wherein the receiver failed to meet the requirements and what action was taken to correct the difficulty. In some cases it was determined that the specification was in error and amendments were made which would make the requirements of the specification more realistic. In a few other cases, before production could begin, waivers to MIL-R-6201 had to be given. In the presentation of the data, the applicable requirements of Specification MIL-R-6201 will be given, the data will be presented and then comment made regarding any amendments or waivers necessary before production approval was granted.

SECTION II - TEST RESULTS

In the performance of the tests the following test equipment was used:

TABLE I
TEST EQUIPMENT USED

Electronic Voltmeter	-	Ballantine Laboratories, Boonton, N. J. Model 300 #830 and #2719
Signal Generator	-	Boonton Radio Corp., Boonton, N. J. Model 211 #215 Model SG-1 #4

TABLE I - continued

TEST EQUIPMENT USED

Glide Slope Test Set	-	Boonton Radio Corp., Boonton, N. J. Type 212-X #6
Standard Signal Generator	-	Measurements Corp., Boonton, N. J. Model 80 #2333
D.C. Microammeter	-	Weston Electrical Inst. Corp., Newark, N. J. Model 1 #57502 and #57501 Model 430 #28107
Vacuum Tube Voltmeter	-	Hewlett Packard Co., Palo Alto, Calif. Model 410 A #Q1064
D.C. Voltmeter	-	Weston Electrical Inst. Corp., Newark, N. J. Model 279 #41923
Power Output Meter	-	General Radio Corp., Cambridge, Mass. Type 583-A #1400 and #1279
Variable Frequency Electronic Generator	-	Communications Meas. Lab., New York, N. Y. Model 1420 #205
Test Set TS-352/U	-	Weston Elect. Inst. Corp., Newark, N. J. Model 972 Multimeter #495
Audio Oscillator	-	Hewlett Packard, Palo Alto, Calif. Model 200-B #9310 15 A
Electronic Frequency Meter	-	Hewlett Packard, Palo Alto, Calif. Model 500-A #H876
Audio Signal Generator	-	Hewlett Packard, Palo Alto, Calif. Model 205 AG #4413

Unless otherwise specified the tests were conducted under standard test conditions which consisted of: 115 volts, 400 cycles AC voltage; 26.5 volts DC voltage; 40% of each 90- and 150-cycle modulation voltages adjusted so as to produce 80% peak modulation; 700 microvolts of RF input in series with 52 ohms; three cross-pointer indicators and two flag alarm indicators. The receiver used during each test will be specified in accordance with the nameplate appearing on the receiver, e. g., Crosley #1 or Pacific Mercury #5315. Military Specification MIL-R-6201 will hereafter be referred to as MIL-R-6201.

SENSITIVITY, FLAG ALARM CHARACTERISTICS AND AUTOMATIC GAIN CONTROL

Paragraph 3.3.1.11 of MIL-R-6201 specifies that "the deflection sensitivity shall be 90 microamperes in each of the three load indicators with standard test conditions and with normal setting of the deflection sensitivity control." Paragraph 3.3.1.12 specifies that when the receiver is adjusted to produce these 90 microamperes, a deflection of 80 microamperes shall be obtained on all channels with an RF input of 20 microvolts or less. (This characteristic is referred to as RF Sensitivity.)

Paragraph 3.3.1.17 states that "when standard test conditions prevail and the receiver is adjusted for standard deflection sensitivity... the audio as measured at the filters shall be within the limits of 0 db and -2 db for any RF signal level between 40 and 100,000 microvolts." (This is referred to as Course Softening.)

3.3.1.23 of MIL-R-6201 specifies that as the RF input is varied from 20 to 100,000 microvolts the balance shall not change by more than 5 microamperes. Also in changing from one channel to another the course width shall not change more than 6 microamperes (course width is defined as the sum of the deflection sensitivities for the plus 2 db and minus 2 db audio ratio conditions) nor shall the balance change more than 3 microamperes.

TABLE II
R.F. INPUT VS OUTPUT

Crosley #1 Receiver

R.F. In.	90c	Bal.	150c	Total	Flag	Audio	Diode
			Channel 1-329.3 mc				
10	85	2(150)	91	176	308	42.0	1.10
20	97	1(150)	101	198	340	42.0	1.38
50	94	0	97	191	332	39.4	1.62
75	92	0	94	186	325	38.5	1.70
100	90	0	92	182	318	37.5	1.75
200	86	0	87	173	302	36.6	1.88
500	80	0	82	162	283	33.5	2.00
1k	76	0	78	154	270	32.0	2.10
2k	72	0	74	146	260	30.0	2.19
5k	67	0	71	138	245	28.7	2.30
10k	65	0	68	133	235	27.5	2.39
20k	62	1(150)	66	128	225	26.5	2.48
50k	58	2(150)	62	120	212	24.8	2.56
100k	54	2(150)	59	113	200	23.5	2.62
			Channel 10-332.0 mc				
10	62	3(150)	65	127	220	38.5	
20	100	1(150)	102	202	348	44	1.20
50	99	0	100	199	342	41	1.46
75	96	0	97	193	332	39.5	1.54
100	94	0	95	189	328	38.8	1.62
200	90	0	90	180	310	36.5	1.75
500	83	0	83	166	290	34	1.90
750	80	0	81	161	282	33	1.96
1k	78	0	80	158	278	32.2	2.00
2k	74	0	76	150	264	30.6	2.10
5k	70	0	72	142	252	29.2	2.22
10k	68	0	70	138	242	28.2	2.3

TABLE II - continued

R.F. INPUT VS OUTPUT

Crosley #1 Receiver

R.F. In.	90c	Bal.	150c	Total	Flag	Audio	Diode
			Channel 10-332.0 mc				
20k	65	0	68	133	232	27.1	2.38
40k	61	0	65	126	222	26.0	2.46
100k	56	2(150)	60	116	205	24.0	2.64
			Channel 20-335.0 mc				
10	-	-	-	-	-	-	-
20	40	6(150)	68	108	235	34	-
50	102	3(90)	100	202	345	42	1.46
75	103	4(90)	98	201	345	42	1.56
100	100	4(90)	95	195	335	40	1.59
200	96	4(90)	91	187	322	38	1.73
500	90	4(90)	86	176	304	36	1.90
1k	86	3(90)	82	168	290	34	2.00
2k	82	3(90)	78	160	278	32.5	2.10
5k	77	3(90)	74	151	262	31	2.21
10k	74	2(90)	72	146	252	29.8	2.30
20k	71	2(90)	70	141	243	28.8	2.39
50k	66	1(90)	66	132	230	27.0	2.50
100k	62	1(90)	62	124	215	25.0	2.56

TABLE III
AUTOMATIC GAIN CONTROL

Crosley #1 Receiver 332.0 mc

R.F. Input	2 db 90	2 db 150	Total	Db (Total)
20	100	102	204	1.98
700	80	81	161	0
14k	67	69	136	-1.44
100k	56	60	116	-2.84

TABLE IV
SENSITIVITY VS CHANNEL FREQUENCY

Frequency	2 db 90	Flag	R.F. Sensitivity (#5316)
329.3	87	340	17.0
329.6	87	340	17.0
329.9	87	340	18.0
330.2	88	341	16.0

TABLE IV - continued

SENSITIVITY VS CHANNEL FREQUENCY

Frequency	2 db 90	Flag	R.F. Sensitivity (#5316)
330.5	87	340	17.0
330.8	87	340	17.0
331.1	88	345	16.0
331.4	88	345	17.0
331.7	88	342	18.0
332.0	88	345	18.0
332.3	89	350	22.0
332.6	88	345	18.0
332.9	88	348	19.0
333.2	89	350	17.0
333.5	88	349	19.0
333.8	88	348	17.0
334.1	88	345	18.0
334.4	88	345	14.0
334.7	90	355	16.0
335.0	-	-	18.0

These data indicate that the receiver met all the requirements for Deflection Sensitivity and RF Sensitivity with regard to input variations and channel changes. Channel 20, 335.0 megacycles, of Crosley #1 Receiver was found to have a defective crystal which accounts for its poor response and subsequent failure on that channel The Course Softening characteristic of this receiver was designed to meet the specification as it was later amended.

During the initial design of the receiver it was determined that several amendments were necessary and have been incorporated in Specification MIL-R-6201A, dated 15 September 1951, which is now being used for all production. One of these changes concerns course softening. It was decided that the course softening requirements should be changed to partially agree with those of the Civil Aeronautics Administration (CAA), and so as to fix more rigid limits on the design. Originally a course softening control was included in the circuit but this was deleted in favor of a fixed amount of softening. The requirements of MIL-R-6201A regarding course softening are as follows:

RF Input - Microvolts	Deflection Sensitivity - DB
20	-1 to +3
700	0
14,000	-1 to -3
100,000	-1 1/2 to -4

Crosley #1 Receiver met these requirements.

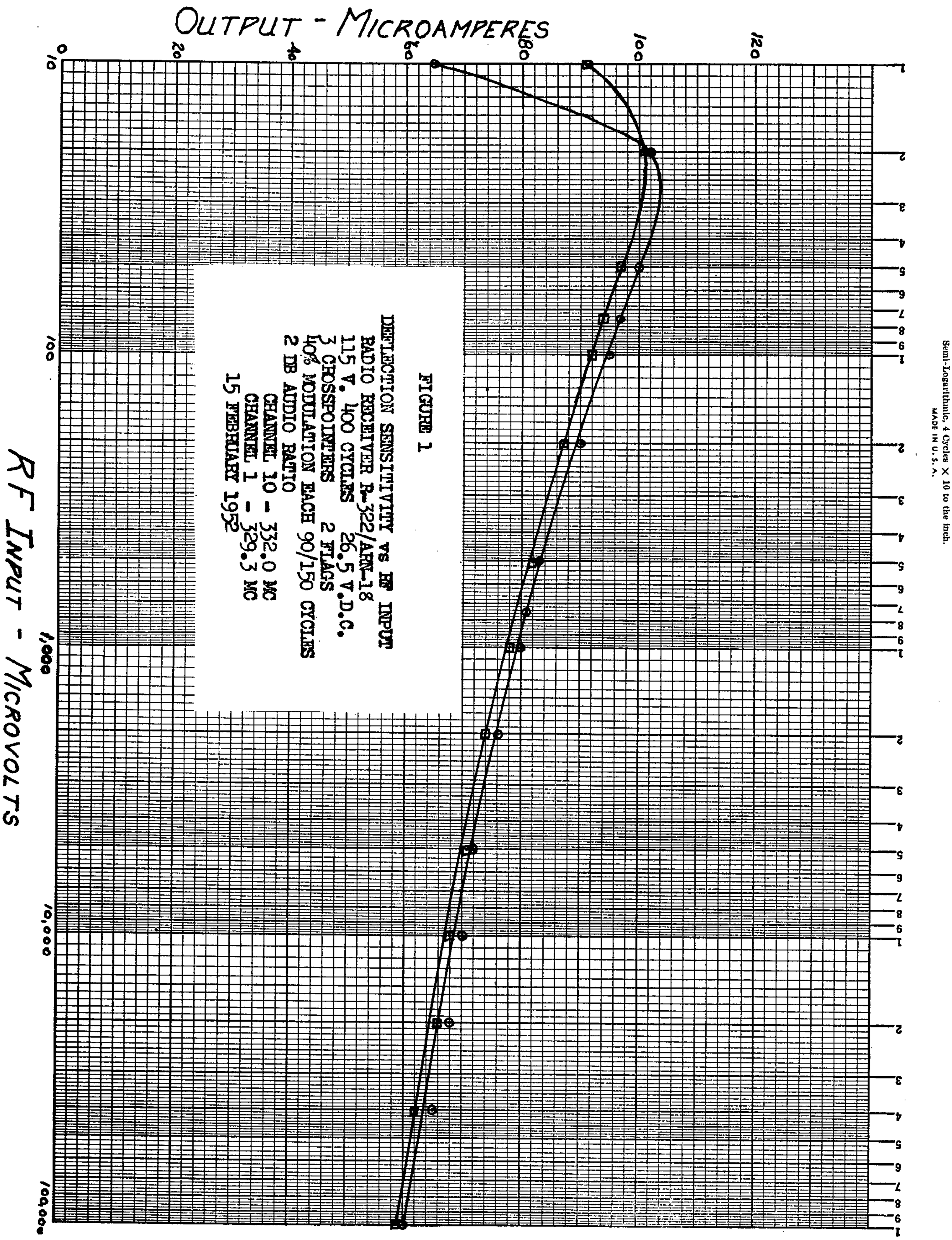

FIGURE 1

DEFLECTION SENSITIVITY vs RF INPUT
RADIO RECEIVER R-322/ARN-18
115 V. 400 CYCLES 26.5 V.D.C.
3 CROSSPOINTERS 2 FLAGS
40% MODULATION EACH 90/150 CYCLES
2 DB AUDIO RATIO
CHANNEL 10 - 332.0 MC
CHANNEL 1 - 329.3 MC
15 FEBRUARY 1952

It was also decided at this time that Standard Deflection Sensitivity should be changed. Hereafter, Standard Deflection Sensitivity will mean with 700 microvolts of RF input and the audio ratio adjusted for 2 db 90/150 cycles, the current through each one of three cross-pointer indicators will be 65 microamperes. The new RF Sensitivity requirements are that when the receiver is adjusted to provide 65 microamperes deflection with 700 microvolts input, the deflection for 20 microvolts input will be greater than 59 microamperes.

SELECTIVITY

3.3.1.13 of MIL-R-6201 specifies that at any resonant frequency of the receiver the total bandwidth shall be as indicated below:

Ratio	Total Bandwidth
6 db	More than 135 kc
60 db	Less than 450 kc
75 db	Less than 600 kc

The data included below indicate that the receiver meets this requirement except at the 60 db point. MIL-R-6201A has the 60 db point bandwidth amended to read "Less than 475 kc," as this figure is more realistic designwise.

TABLE V
SELECTIVITY

Pacific Mercury #5316

R.F. Input	Db	Generator Dial Setting			Bandwidth kc
		Above	Res.	Below	
10	0		335.015		
20	6	335.125	(335.050)	334.976	149
10k	60	335.285		334.834	451
56.2k	75	335.337		334.785	552

Dissymmetry at 60 db equals 8.43%
Dissymmetry at 75 db equals 7.96%

RECEIVERS IN PARALLEL

MIL-R-6201 specifies in 3.3.1.3 that "the operation of two receivers connected in parallel to a single antenna shall not result in more than a 4 db loss." The data indicate that these receivers easily met this requirement of the specification.

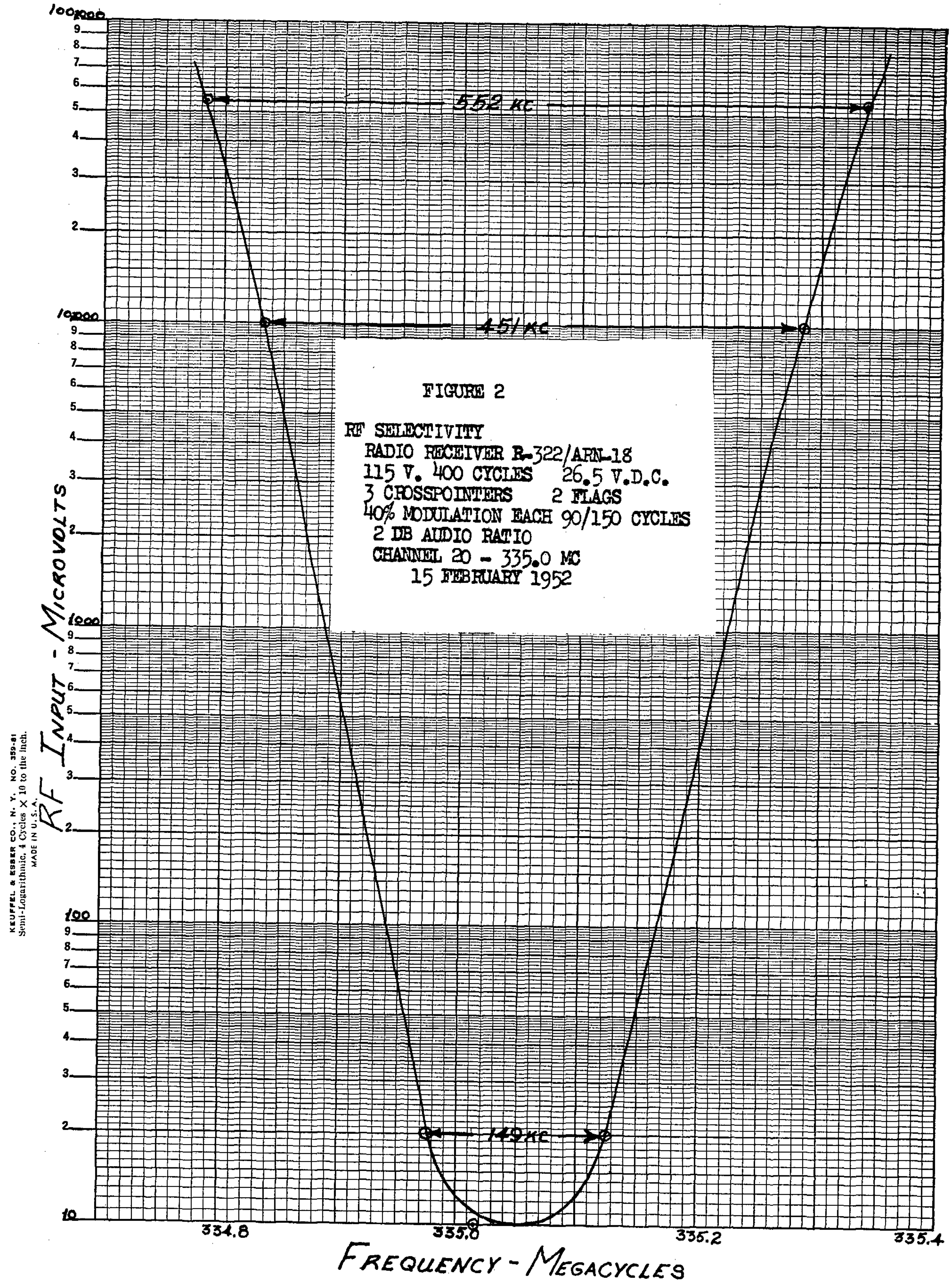

FIGURE 2

RF SELECTIVITY
RADIO RECEIVER R-322/ARN-18
115 V. 400 CYCLES 26.5 V.D.C.
3 CROSSPOINTERS 2 FLAGS
40% MODULATION EACH 90/150 CYCLES
2 DB AUDIO RATIO
CHANNEL 20 - 335.0 MC
15 FEBRUARY 1952

TABLE VI
RECEIVERS IN PARALLEL

Crosley #2 and Pacific Mercury #5315

		332 mc				Std. Conditions
	R.F. Input	2 db 90	Bal	2 db 150	Total	Flag
#5315 alone	700	69	4(90)	59	128	330
	50K	49	2(90)	44	93	250
#5315 (#2 in parallel)	700	71	4.5(90)	59.5	130.5	335
	50K	50	2(90)	45	95	250

The RF Sensitivity of #5315 alone was 15 uv. It was 22 uv when #2 was connected in parallel.

UNDESIRED RESPONSES

3.3.1.14 of MIL-R-6201 specifies that "the following requirements shall apply to all undesired signals regardless of type of service or modulation over a frequency range of 70 to 1700 megacycles:

Adjacent Channel - 90 db down
Image - 90 db down
Intermediate Frequency - 100 db down

All other spurious responses found in the pass band shall be at least 75 db." The data show that the receiver fell considerably short of the specification limits.

In view of the fact that adjacent channel rejection is determined by the selectivity of the receiver, the 90 db requirement for adjacent channel was impractical. Therefore in MIL-R-6201A this requirement was changed to 70 db. Also, before production began on the three contracts, waivers were granted so as to specify an image rejection of 75 db, an intermediate frequency rejection of 90 db, and a rejection of all other spurious signals of at least 70 db. Production receivers meet these requirements.

TABLE VII
UNDESIRED RESPONSES

Pacific Mercury #5316

Adjacent Channel Rejection - greater than 70 db.
Image Rejection - greater than 70 db.
IF Rejection - greater than 80 db.
All Other Spurious Responses at Least 74 db down.

HARMONIC DISTORTION

MIL-R-6201 specifies that for any RF signal between 40 and 100,000 microvolts modulated simultaneously with equal amounts of 90- and 150-cycle modulating voltages (adjusted so as to produce 90% peak modulation) the percentage total harmonic distortion shall not exceed 5% nor shall the intermodulation exceed 10%. The data show that this requirement is easily met.

TABLE VIII
HARMONIC DISTORTION & INTERMODULATION

Freq.	40 uv	700 uv	15 k uv	50 k uv
30	0	0	0	0.46
60	3.2	3.2	3.2	3.2
90	95.0	96.0	96.0	97.0
120	.45	1.0	1.2	1.7
150	100	100	100	100
180	.7	.8	1.20	1.30
210	1.5	1.45	1.30	3.80
240	.12	.35	.50	.50
270	.55	.60	.70	.70
200	.40	.60	.60	.90
330	.32	.50	.60	.38
360	.10	.12	.18	.28
390	.12	.11	.10	3.30
420	.24	.55	.75	5.20
450	.40	.46	.42	1.50
480	.10	.23	.35	.08
Distortion				
Harmonic	1.06%	1.26%	1.58%	2.39%
Intermodulation	3.59%	3.74%	3.83%	8.35%

CROSS MODULATION

In accordance with the requirements of MIL-R-6201 this receiver is designed so that it protects against any undesired glide slope signal spaced between 0.6 and 5.7 megacycles away from the desired channel. Even when the desired signal was 20 microvolts (modulated with equal amounts of 90 and 150 cycles adjusted for 90% peak modulation) and the undesired signal was 100,000 microvolts (adjusted for 80% modulation of 150 cycles) there were no adverse effects caused by the presence of the undesired signal.

RANGE OF CONTROLS

MIL-R-6201 specifies that under standard conditions and with the deflection sensitivity adjusted for 90 microamperes at 200 microvolts input the following ranges of controls shall be available: flag alarm - maximum of 700 microamperes in each of three load indicators; deflection sensitivity - minimum of 35 or less and maximum of 135 or more; balance control - at least 25 microamperes on either side of true balance. During the design it was agreed to amend the specification to the extent that the flag alarm control should provide at least 550 microamperes in each of three indicators when the input was 100,000 microvolts. The other requirements remained the same. Data included below indicate that the receivers met this portion of the specification.

TABLE IX
RANGE OF CONTROLS

Crosley #1 Receiver Std. Conditions		
Flag Alarm Control		
200 uv	2 db 90	40 ua minimum
		890 ua maximum
Balance Control		
200 uv	0 db	45 ua on 90c side
		66 ua on 150c side
Sensitivity Control		
200 uv	2 db 90	17 ua minimum
		97 ua maximum
Audio Control (Sensitivity Control Wide Open)		
200 uv	2 db 90	33 ua minimum
		greater than 150 ua maximum

CURRENT DRAIN

Paragraph 3.3.1.5 of MIL-R-6201 specifies that the alternating current consumption shall not exceed 1.0 amperes at 115 volts rms, and the direct current consumption shall not exceed 2.0 amperes at 26.5 volts. The DC is used for all filaments and relay operation. The results shown below indicate that the receiver easily met this requirement of the specification.

TABLE X
CURRENT DRAIN

Crosley #2 Receiver		Std. Condition
AC Current	-	0.27 amperes
DC Current	-	1.00 amperes

WARM-UP CHARACTERISTICS

MIL-R-6201 specifies that after a five minute warm-up the deflection sensitivity shall not change more than three microamperes nor the balance more than two microamperes. The data show the receiver met this requirement.

TABLE XI
WARM-UP CHARACTERISTICS

Time Set On (minutes)	2 db 90	Bal
1	38	0
2	38	0
3	38	1(90)
4	38	1(90)
5	40	1(90)
6	40	2(90)
7	40	2(90)
10	40	2(90)

RESONANT FREQUENCY STABILITY

3.3.1.21 specifies that "the variation of the resonant frequency of the receiver with service conditions taken one at a time shall not exceed the following limits when the frequency of the receiver is compared to the assigned channel frequency:

Temperature variations	0.01 percent
All other conditions	0.005 percent."

In view of the fact that the crystal accuracy was 0.005 percent it was impossible to meet the requirements and they were waived to 0.02 percent and 0.01 percent, respectively. The data included show the receiver met these requirements.

TABLE XII
RESONANT FREQUENCY STABILITY

Pacific Mercury #5316

AC Volts	AC Freq	DC Volts	Temp.	Resonant Freq.
115	400	26.5	Room	332.063
120	400	26.5	Room	332.064
110	400	26.5	Room	332.063
115	320	26.5	Room	332.064
115	1700	26.5	Room	332.063
115	400	24.2	Room	332.066
115	400	28.75	Room	332.063
115	400	27	Room	332.040
115	400	26.5	-55°C	332.073
115	400	26.5	+72°C	332.075
115	400	26.5	+55°C	332.065
115	400	26.5	Room	332.066
115	400	26.5	50,000 ft.	332.060
115	400	26.5	Before shock	332.013
115	400	26.5	After shock	332.007
115	400	26.5	After vibration	332.011

SENSITIVITY VS AC AND DC VOLTAGES

3.3.1.22 specifies that the deflection sensitivity shall not change more than 6 microamperes with changes in DC voltage or 5 microamperes with variations in AC voltage and frequency. 3.3.1.23 stipulates that the balance shall not change more than 2 microamperes with changes in DC voltage or 3 microamperes in AC voltage and frequency. The data indicate that in most cases the specification was met. At low voltages, though, the deflection sensitivity dropped off perceptibly. Before production was allowed to begin some minor changes were made to correct this difficulty.

TABLE XIII
SENSITIVITY VS DC & AC VOLTAGES

AC Freq	AC Volts	DC Volts	2 db 90	Bal	2 db 150	Total	Flag
400	115	26.5	66	3(90)	64	130	360
400	110	26.5	66	3(90)	64	130	350
400	120	26.5	65	3(90)	63	128	345
400	115	29	69	3(90)	67	136	365
400	120	29	68	3(90)	65	133	365
400	110	29	69	3(90)	67	136	365
400	115	24	61	2(90)	60	121	325
400	120	24	61	2(90)	58	119	325
400	110	24	62	2(90)	63	125	330
400	115	26.5	64	1(90)	65	129	350
320	115	26.5	64	1(90)	65	129	350
1700	115	26.5	64	.5(90)	66	130	352

TEMPERATURE AND ALTITUDE REQUIREMENTS

MIL-R-6201 specifies in 3.3.1.22 that temperature variations should not cause the deflection sensitivity to change more than 10 microamperes and the deflection sensitivity should not change more than 5 microamperes when the barometric pressure is changed from room ambient to 3.4 inches of mercury (approximately 50,000 feet). 3.3.1.23 specifies that temperature variations should not cause the balance to change more than 7 microamperes nor should altitude tests cause the balance to vary more than 3 microamperes. The receiver met this portion of the specification.

TABLE XIV
TEMPERATURE VARIATIONS

Pacific Mercury #5316

Temp.	2 db 90	Bal	2 db 150	Total	Flag
		329.3 mc			
Room	76	10(90)	57	133	340
-55°C	68	8(90)	56	124	290
+72°C	78	9(90)	63	141	370

TABLE XIV - continued

TEMPERATURE VARIATIONS

Pacific Mercury #5316

Temp.	2 db 90	Bal	2 db 150	Total	Flag
+55°C	72	5(90)	62	134	350
Room	75	9(90)	59	134	335
50,000 ft.	76	11(90)	57	133	335
			332.0 mc		
Room	71	10(90)	54	125	320
-55°C	67	8(90)	55	122	285
+72°C	78	9(90)	60	138	370
+55°C	72	6(90)	63	135	360
Room	75	9(90)	58	133	340
50,000 ft.	74	10(90)	56	130	330
			335.0 mc		
Room	74	9(90)	55	129	325
-55°C	66	8(90)	54	120	285
+72°C	79	9(90)	62	141	375
+55°C	76	6(90)	64	140	365
Room	73	9(90)	58	131	330
50,000 ft.	74	10(90)	56	130	325

Crosley #1 Receiver

Temp.	2 db 90	Bal	2 db 150	Total	Flag
			329.3 mc		
Room	66	2(90)	64	130	380
-55°C	64	3(150)	70	134	370
+72°C	67	3(150)	72	139	432
+55°C	66	2(150)	70	136	420
Room	65	0	66	131	390
			332.0		
Room	71	2(90)	67	138	418
-55°C	66	3(150)	73	139	373
+72°C	70	2(150)	74	144	458
+55°C	64	2(150)	69	133	420
Room	68	0	69	137	420
			335.0		
Room	67	2(90)	64	131	400
-55°C	68	4(150)	78	146	405
+72°C	67	3(150)	72	139	432
+55°C	66	2(150)	71	137	420
Room	65	.5(150)	66	131	395

HUMIDITY TESTING

MIL-R-6201 specifies that after 48 hours of humidity at 95% relative humidity and 50°C the deflection sensitivity shall not change by more than 14 microamperes nor shall the balance change more than 10 microamperes. The First Article failed to meet this requirement. Subsequent investigation revealed that the relays were faulty, the terminal board insulation material was inadequate, as were the insulating forms used in the intermediate frequency transformers.

The relays had been zinc dichromate plated, and zinc salts which formed in humidity caused the relays to become inoperative. These relays were replaced by cadmium plated relays with iridite. Terminal boards were made of a different material which had a higher insulation resistance under the various service conditions. The IF transformers were redesigned so as to use a better phenolic form and to use "Formvar" type insulated wire for the windings to improve the insulation resistance.

Data included below show the results of humidity tests conducted at W-P AFB on the First Article and on a production item manufactured at Emerson Radio and Television Corporation after the aforementioned changes had been made. The latter data indicate the receiver met the requirements of the specification.

TABLE XV
HUMIDITY TESTING

Emerson #3544

Status	2 db 90	Bal	2 db 150	Total	Flag
		329.3 mc			
Before	64	1(150)	65	129	285
1 Hr Drying	60	6(90)	48	108	235
96 Hrs Drying	56	11(90)	56	112	300
		332.0 mc			
Before	64	0	64	128	285
1 Hr Drying	63	8(90)	47	110	240
96 Hrs Drying	74	10(90)	55	129	291
		335.0 mc			
Before	65	0	66	131	290
1 Hr Drying	60	8(90)	45	105	230
96 Hrs Drying	63	10(90)	56	119	290

After drying 1 hour 10 channels were inoperative.
After drying 48 hours all channels were operative.

TABLE XV - continued

HUMIDITY TESTING

Emerson #21 Run at Emerson Status	2 db 90	Bal		2 db 150	Total	Flag
			329.3			
Before	66	2(150)		70	136	410
2 Hrs Drying	61	1(150)		64	125	350
			332.0			
Before	66	3(150)		68	134	400
2 Hrs Drying	62	2(150)		66	128	365
			335.0			
Before	66	2(150)		70	136	400
2 Hrs Drying	60	1(150)		62	122	355

After drying 5 minutes all channels were operative.

DEFLECTION LINEARITY

MIL-R-6201 specifies that variation of the audio ratio between 0 and 4 db shall result in a linear deflection sensitivity within 10% or 3 microamperes, whichever is greater. The data show this requirement is met by the receiver.

TABLE XVI
DEFLECTION LINEARITY

Crosley #1 Receiver

Audio Db Ratio	Deflection Sensitivity
-4	75 ua
-2	38
-0.5	10
0	0
0.5	9
2	38
4	74

SHOCK TEST

Paragraphs 3.3.1.22 and 3.3.1.23 of MIL-R-6201 specify that the deflection sensitivity shall not change more than 10 microamperes nor the balance more than 5 microamperes when the receiver is subjected to 10 shocks of 30g impact in each of three directions. During this test two resistors were broken. Upon replacement the data below were taken and indicate the receiver easily met the requirements of the specification.

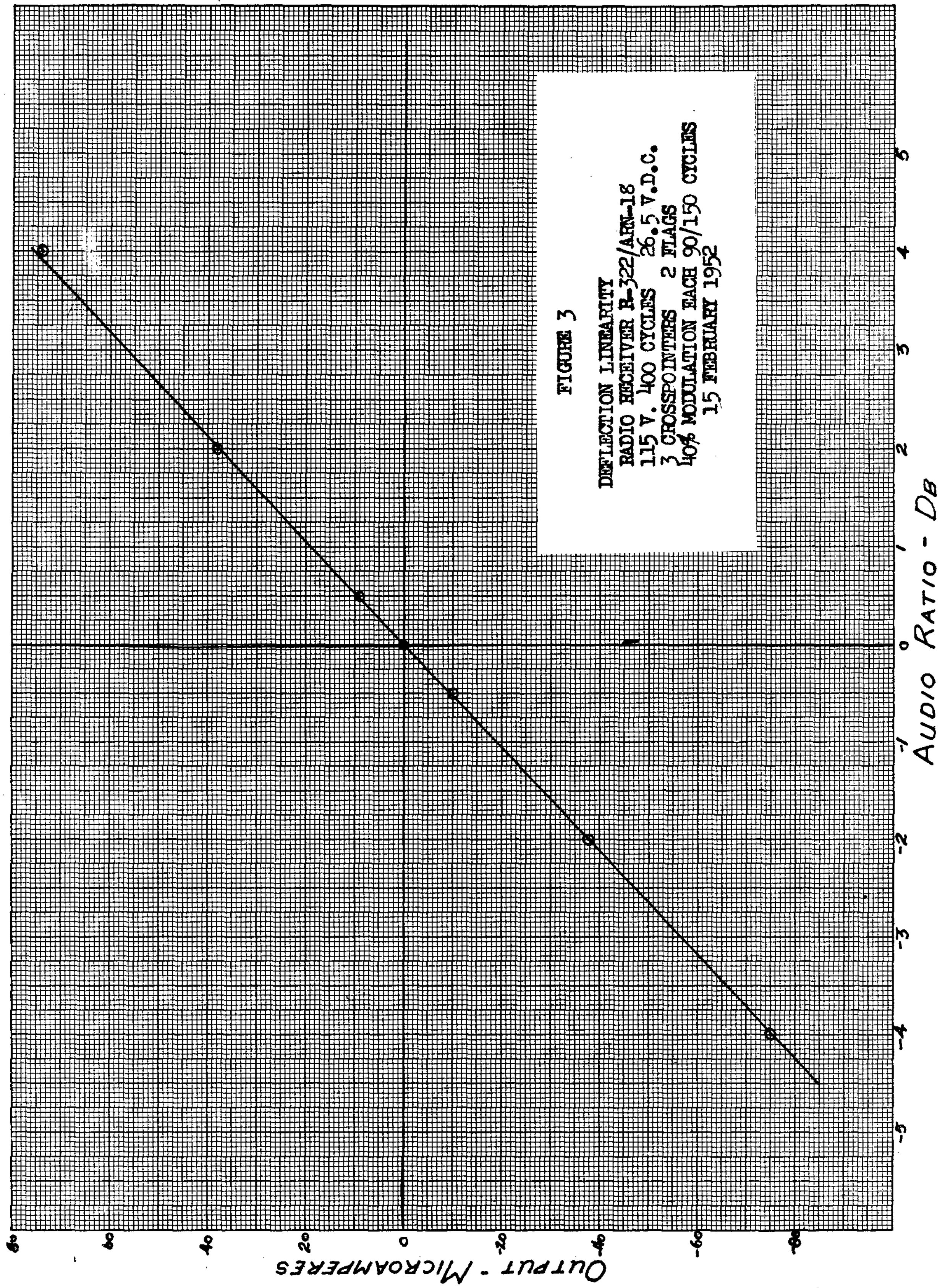

FIGURE 3
DEFLECTION LINEARITY
RADIO RECEIVER R-322/ARN-18
115 V. 400 CYCLES 26.5 V.D.C.
3 CROSSPOINTERS 2 FLAGS
40% MODULATION EACH 90/150 CYCLES
15 FEBRUARY 1952

TABLE XVII
SHOCK TEST

Pacific Mercury #5315 Standard Conditions

Status	2 db 90	Bal	2 db 150	Total
		329.3		
Before	73	1(90)	68	141
After	70	1(90)	66	136
		332.0		
Before	69	2(90)	62	131
After	70	1(90)	64	134
		335.0		
Before	69	2(90)	63	132
After	70	2(90)	64	134

VIBRATION TEST

MIL-R-6201 specifies that as a result of vibration testing the deflection sensitivity shall not change more than 6 microamperes nor shall the balance change by more than 3 microamperes. Data included below indicate that these requirements were met.

TABLE XVIII
VIBRATION

Status	2 db 90	Bal	2 db 150	Total
		329.3		
Before	70	1(90)	66	136
After	71	0	68	139
		332.0		
Before	70	1(90)	64	134
After	69	0	66	135
		335.0		
Before	70	2(90)	64	134
After	68	0	65	133

LIFE TEST

Specification MIL-R-6201 stipulates that the radio receiving set shall provide life ranging up to 1000 flying hours with only minor repairs. This characteristic was to be judged on the basis of a 500-hour life test. During this life test there were no failures of any component or part and the only effect was an increase in deflection sensitivity and a slight decrease in RF Sensitivity. At the end of the life test the RF Sensitivity was 24 microvolts, as compared to 18 microvolts at the inception of the life test.

TABLE XIX
LIFE

Crosley #2 Date	Standard Conditions 2 db 90	Bal	2 db 150	Total	Flag	Frequency
2 Oct 51	70	2(90)	72	142	340	331.982
5 Oct 51	70	4(90)	66	136	330	331.998
8 Oct 51	70	2(90)	72	142	340	331.978
10 Oct 51	75	2(90)	74	149	360	331.990
12 Oct 51	70	0	74	144	350	331.995
15 Oct 51	77	2(90)	76	153	375	331.992
17 Oct 51	78	2(90)	79	156	380	331.992
19 Oct 51	82	3(90)	80	162	390	331.990
22 Oct 51	76	1(90)	80	156	385	331.990
24 Oct 51	78	3(90)	76	154	370	331.985

MECHANICAL CHARACTERISTICS

The final design adopted by the three contractors represented a reduction in size and weight from either one of the development models. The addition of a 400-cycle plate power supply eliminated the use of a dynamotor. This enabled them to design the case so that the mounting would not project beyond the end of the receiver to any great extent. The mounting is an all-metal type mounting. The receiver case size, including handle, is 4 7/8 inches wide by 7 1/2 inches high by 14 inches long, and the weight is 13 1/2 pounds. The over-all size of the receiver and mounting is 5 1/4 inches wide by 9 inches high by 14 1/2 inches, and the total weight is 15 1/4 pounds. The mounting is provided with a positioning-extracting device.

FLIGHT TESTING

After the bench testing was complete the receiver was flight tested in a B-17 aircraft assigned to W-P AFB. Several approach landings were made to ascertain satisfactory operation. On the first flight the damping condenser of 1200 microfarads was not on the indicator and unsatisfactory operation resulted, for the system was too sensitive. Subsequent flights resulted in very satisfactory performance. The next flight plan required the pilot to climb to 10,000 feet and fly outbound until the glide slope flag appeared. The pilot then made a procedure turn to see whether the flag again disappeared as the plane headed toward the landing area. If it disappeared the pilot was to repeat the procedure until the maximum range of the receiver was determined at this altitude. This range was found to be approximately 110 miles.

The third and final flight plan required the pilot to fly outbound on the glide slope until the flag appeared, do a procedure turn and see whether the flag disappeared when the plane headed for the landing area. If it disappeared, the pilot was to repeat the procedure until the maximum range of the receiver was found or the aircraft reached its ceiling. It was found that at 35,000 feet, the ceiling of the B-17, at a distance of approximately 140 miles from the landing area the glide slope signal was still being received in sufficient strength, when heading toward the runway, to cause the glide slope flag to disappear. These flights were conducted using Antenna AT-106/ARN, a flush-mounted, bathtub type antenna designed by the C&N Laboratory, mounted in the nose of the aircraft. Similar results have also been obtained using a commercial type Collins 37P-2 (Antenna AT-326/ARN) mounted externally on the nose.

III - EVALUATIONS AND CONCLUSIONS

The basic electrical specifications as met by this receiver can be summarized as follows: there are 20 channels of operation spaced 0.3 megacycles apart in the band from 329.3 to 335.0 megacycles. The resonant frequency stability under all service conditions is 0.02% or better. With the balance adjusted for 0 microamperes and the total deflection sensitivity adjusted for 130 microamperes in each of three load indicators, the deflection sensitivity stability under all service conditions is 130 ± 14 microamperes, while the on course (balance) stability is 0 ± 10 microamperes.

The rejection of undesired responses is at least 74 db with adjacent channel rejection being 70 db or greater. The selectivity curve is such that at the 6-db point the total bandwidth is greater than 135 kc and at the 75-db point the bandwidth is less than 600 kc. Harmonic distortion is less than 5% and intermodulation is less than 10%. Cross modulation has essentially no effect on the proper operation of the receiver nor does 2 volts of ripple of any frequency between 30 and 20,000 cycles per second when injected into the AC or DC power leads.

The receiver and mounting have a vibration resonant frequency less than 12 cycles per second in all directions, and neither vibration nor shock, up to 30 g, materially affects the operation of the receiving set. The mounting operates very effectively under all service conditions including cold temperatures.

Flight results proved this receiver to be the most sensitive glide slope receiver tested to date, and the range of 140 miles obtained is considered excellent. This range will enable aircraft flying at high altitudes to pick up the glide slope at the high altitude and fly it right in to the landing area. Judging from the results of the life test, this receiver should be a highly reliable receiver requiring very little maintenance.

This receiver represents a substantial improvement over Radio Receiving Set AN/ARN-5( ) and will replace it as a Standard Item as soon as service tests can be conducted. At the present time both the AN/ARN-5( ) and the AN/ARN-18 are classified "Substitute Standard."

In evaluating this radio receiving set it was believed that the design represents the ultimate that the present state of the art permitted. In view of the urgency attached to the production, the contractors were given production approval in September 1951 during the conducting of pilot runs. As of 1 February 1952 approximately 4000 Radio Receiving Sets AN/ARN-18 have been built and delivered by the three contractors.

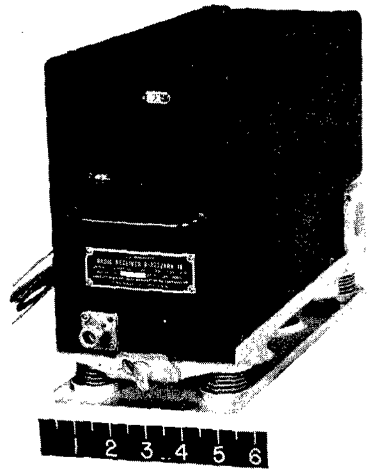

Fig. 4 Radio Receiver R-322/ARN-18 on mounting MT-691/ARN-18 (Diagonal Front View)

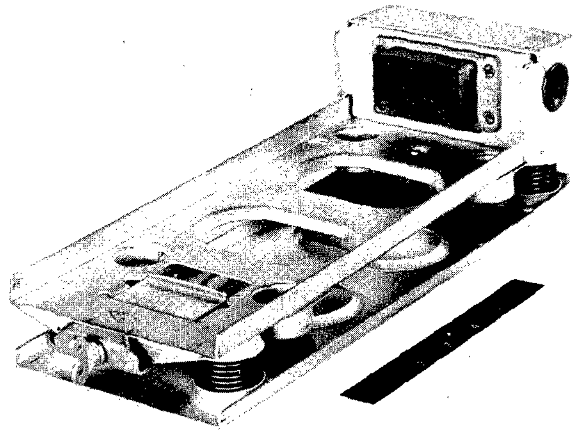

Fig. 5 Mounting MT-691/ARN-18 (Diagonal Front View)

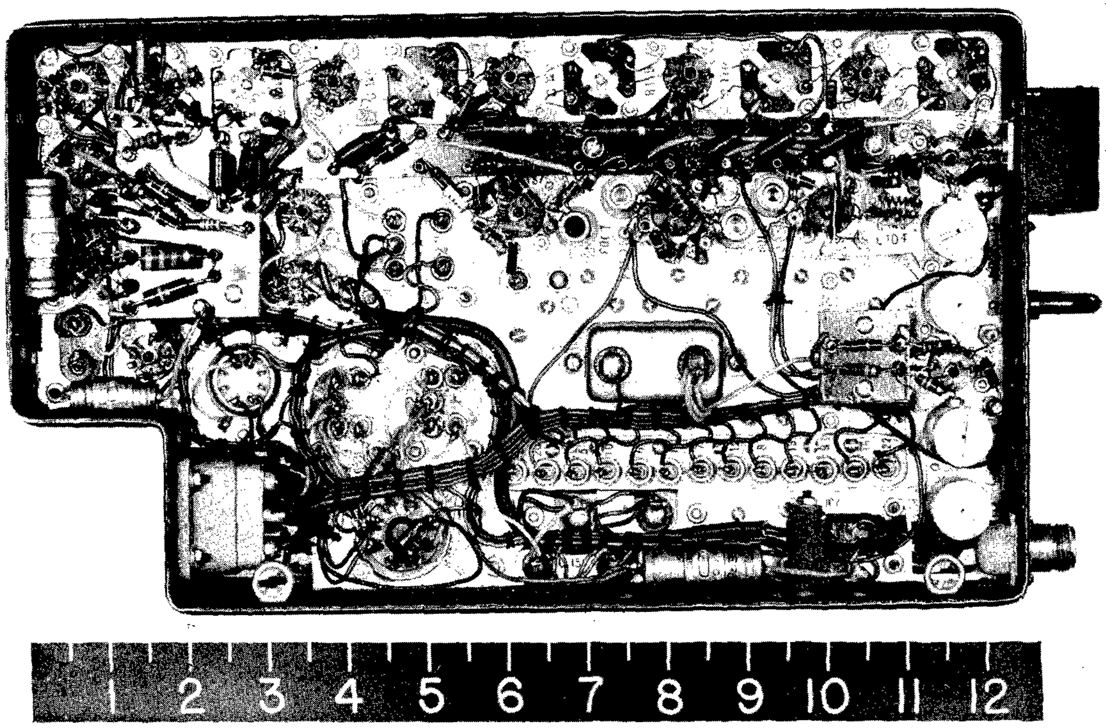

Fig. 6 Radio Receiver R-322/ARN-18 (Interior Left Side View - Dust Cover Removed)

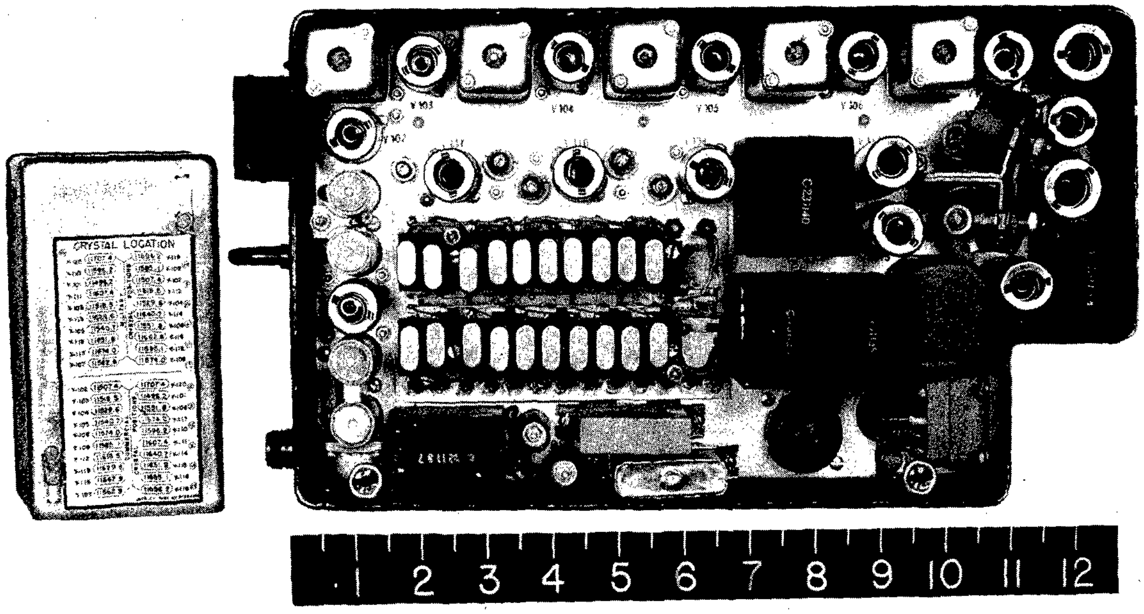

Fig. 7 Radio Receiver R-322/ARN-18 (Interior Right Side View - Dust Cover and Crystal Housing Removed)

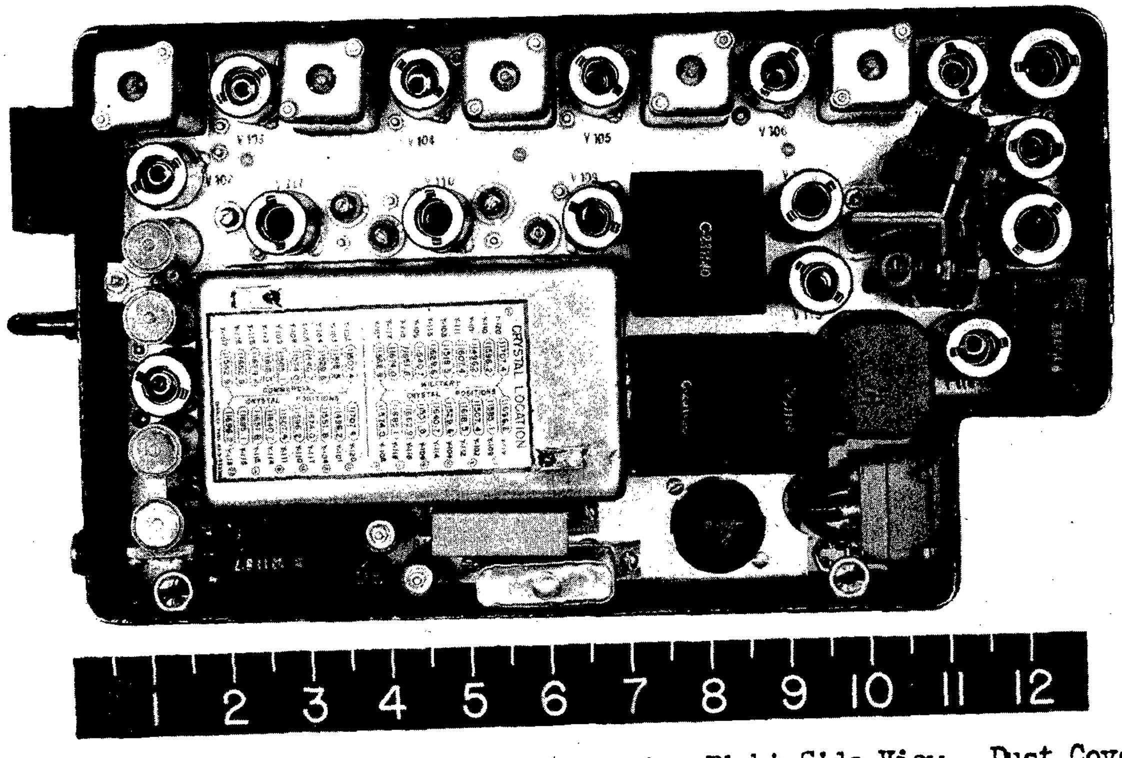

Fig. 8 Radio Receiver R-322/ARN-18 (Interior Right Side View - Dust Cover Removed)

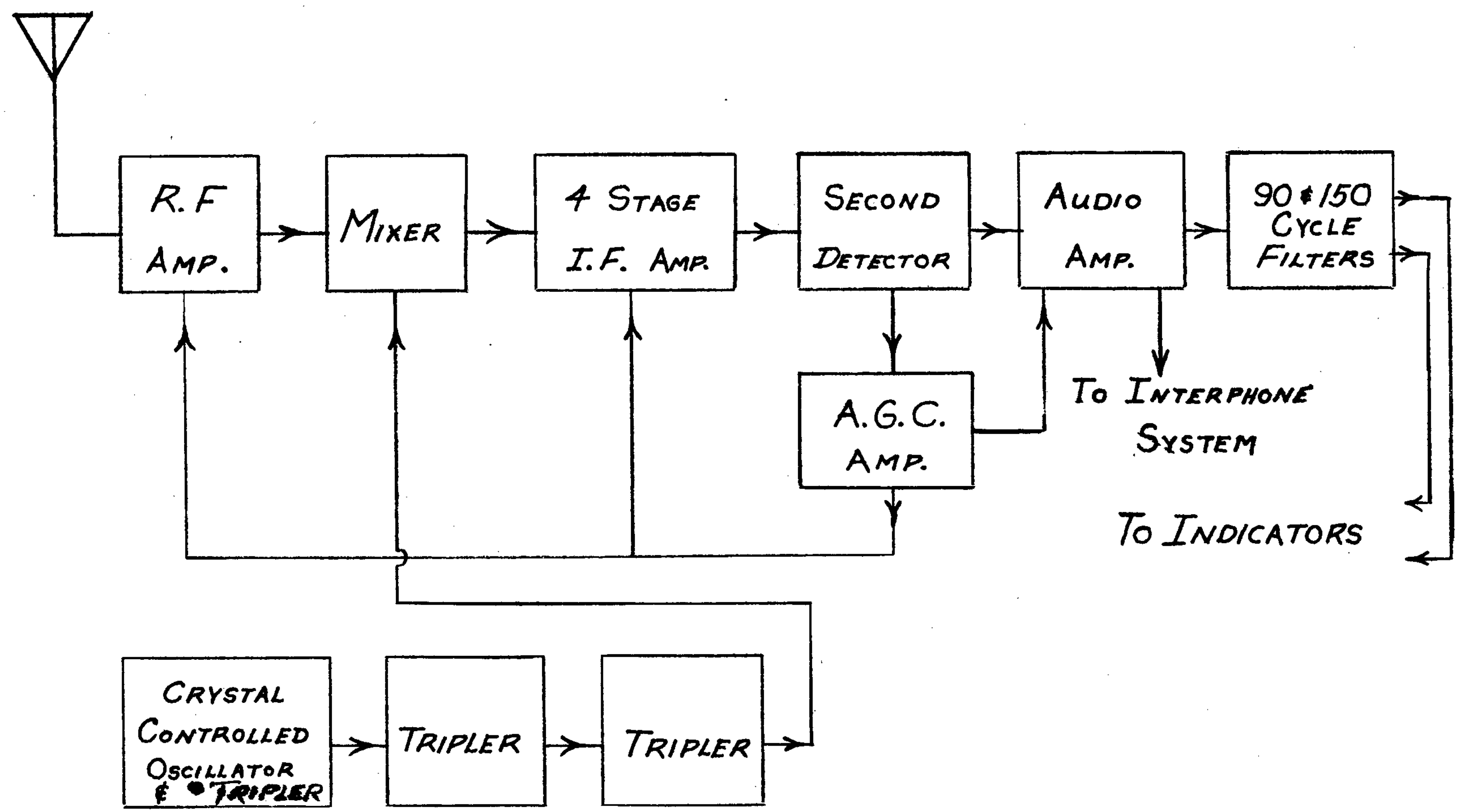

Fig. 9

Block Diagram - Radio Receiver R-322/ARN-18

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